

What is claimed is:

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1. A biometric verification device for providing secure access to a unit connected to the device, the device comprising:
 - a. a biometric sensor capable of sensing a biometric trait of a user that is unique to said user and providing a first signal containing information representing said biometric trait; and
 - b. a processing unit connected to said biometric sensor so as to receive said first signal, said processing unit being adapted to compare said information with biometric data stored in said processing unit representing a biometric trait of an enrolled person, and provide a verification signal indicating whether or not said information corresponds sufficiently with said biometric data to verify said user is said enrolled person, wherein said processing unit completes said comparison and generates said verification signal within 20 seconds of when said biometric sensor senses said biometric trait using no more than 1 W of peak power.
2. A device according to claim 1, wherein said biometric trait is a fingerprint.
3. A device according to claim 1, wherein said biometric trait is an iris pattern from an eye.
4. A device according to claim 1, wherein said processing unit completes said comparison and generates said verification signal using no more than 400 mW of peak power.
5. A device according to claim 1, wherein said processing unit completes said comparison and generates said verification signal within 7 seconds of when said biometric sensor senses said biometric trait.
6. A device according to claim 1, wherein said processing unit stores said biometric data representing a biometric trait of an enrolled person using no more than 1K bytes of data.

- 1 7. A device according to claim 6, wherein said processing unit stores said biometric
2 data representing a biometric trait of an enrolled person using no more than 256
3 bytes of data.
- 1 8. A device according to claim 1, further including one or more batteries that
2 comprise the sole source of power for the device.
- 1 9. A device according to claim 1, wherein said processing unit includes non-volatile
2 memory for storing said biometric data representing said biometric trait.
- 1 10. A device according to claim 1, further including a wireless interface for
2 connecting the device with the unit.
- 1 11. A device according to claim 1, further including a wired interface for connecting
2 the device with the unit.
- 1 12. A device according to claim 1, wherein said processing unit performs said
2 comparison with a false acceptance rate of less than about 0.5% and a false
3 rejection rate of less than about 5%.
- 1 13. A device according to claim 1, further including an external unit connected to said
2 processing unit, said external unit being operable independently of said sensor and
3 processing unit upon receipt of said verification signal indicating said user is said
4 enrolled person.
- 1 14. A device according to claim 13, wherein said external unit is remote from said
2 sensor and processing unit.
- 1 15. A device according to claim 13, wherein said external unit is physically proximate
2 said sensor and processing unit.
- 1 16. A system for performing directional image filtering of a fingerprint image, the
2 image being represented by a plurality of pixels, each having a value and residing
3 in one of a plurality of blocks, the system comprising:

- 1 a. an orientation module that provides an orientation number for each of the
2 blocks of said plurality of pixels, said orientation number representing the
3 approximate orientation of fingerprint ridges in the block; and
4 b. an averaging module that averages each of said pixels with a number of
5 adjacent pixels that are selected as a function of the orientation number for the
6 block in which said each pixel resides.
- 1 17. A system according to claim 16, wherein said orientation module determines said
2 orientation number by calculating for each pixel in said block an X gradient dX
3 and a Y gradient dY , and a ridge slope for said block using the equation $S(dX^2 -$
4 $dY^2)/S(2 * dX * dY)$.
- 1 18. A system according to claim 16, wherein said orientation module uses integers to
2 represent said orientation numbers.
- 1 19. A system for extracting fingerprint minutia points from a first monochrome image
2 containing an x-y array of pixels, each representing either a fingerprint ridge or a
3 fingerprint valley, the x-y array being divided into a plurality of contiguous local
4 blocks, each having a predetermined number of the pixels arranged in rows and
5 columns, each minutia point being one of several types, the system comprising:
6 a. a scanner module that scans lines of pixels in each local block to detect the
7 position of segments of pixels in said each local block representing a
8 fingerprint ridge;
9 b. a comparator module that compares each of said ridge segments detected by
10 said scanner module in each local block with adjacent ridge segments to
11 determine if a minutia point exists, and identifies its position and minutia point
12 type;
13 c. a ridge direction module that determines direction of fingerprint ridges leading
14 to each minutia point determined by said comparator module; and
15 d. a minutia list module that saves said position and type of minutia points
16 determined by said comparator module and fingerprint ridge directions
17 determined by said ridge direction module.

- 1 20. A system according to claim 19, wherein said lines of pixels scanned by said
2 scanning module extend along one of rows or columns of the first monochrome
3 image.
- 1 21. A system according to claim 19, wherein said lines of pixels scanned by said
2 scanning module extend at an angle relative to the rows of the first monochrome
3 image.
- 1 22. A system according to claim 19, wherein said minutia list module saves said
2 positions and types of minutia points, and said ridge directions, for a given
3 fingerprint using less than 1K bytes of data.
- 1 23. A system according to claim 22, wherein said minutia list module saves said
2 positions and types of minutia points, and said ridge directions, for a given
3 fingerprint using less than 256 bytes of data.
- 1 24. A system according to claim 19, wherein said ridge direction module determines
2 which fingerprint ridge leads to a minutia point as a function of minutia point
3 type.
- 1 25. A system according to claim 19, wherein the system extracts fingerprint minutia
2 points from the first monochrome image and from a second monochrome image
3 containing an x-y array of pixels that is a diagonally flipped version of the first
4 monochrome image, further wherein said scanner module includes a ridge
5 orientation module for determining a ridge orientation number for each local
6 block representing the approximate slope of fingerprint ridges in the local block,
7 and said scanner module scans either the first monochrome image or the second
8 monochrome image as a function of said ridge orientation number for the local
9 block being scanned.
- 1 26. A method of extracting minutia points from a first monochrome images
2 containing an x-y array of pixels representing either a fingerprint ridge or a
3 fingerprint valley, the x-y array being divided into a plurality of contiguous local

1 blocks, each having a predetermined number of the pixels arranged in rows and
2 columns, the method comprising the steps of:

- 3 a. scanning lines of pixels in each local block to detect the position of segments
4 of pixels in said each local block representing a fingerprint ridge;
- 5 b. comparing, in each local block, each of said ridge segments detected in said
6 scanning step a with adjacent ridge segments to determine if a minutia point
7 exists, and identifying its position and minutia point type;
- 8 c. determining direction of fingerprint ridges leading to each minutia point
9 determined in said comparison step b; and
- 10 d. creating a minutia list that identifies said position and minutia point type
11 determined in said comparison step b and said fingerprint ridge directions
12 determined in said determining step c.

1 27. A method according to claim 26, wherein said creating step d involves creating
2 said minutia list using less than 1K bytes of data.

1 28. A method according to claim 26, wherein said creating step d involves creating
2 said minutia list using less than 256 bytes of data.

1 29. A method according to claim 26, further involving extraction from the first
2 monochrome image and a second monochrome image that is a diagonally flipped
3 version of the first monochrome image, wherein said scanning step a includes
4 determining a fingerprint ridge orientation number for each local block and
5 scanning either said first monochrome image or said second monochrome image
6 as a function of said orientation number.

1 30. A fingerprint template creation device designed for use with a system in which is
2 stored information representing attributes of a first fingerprint that are unique to a
3 first person having the first fingerprint, the device being usable with a fingerprint
4 sensor that provides an output signal when a user's finger is positioned proximate
5 the sensor, the output signal containing information representing attributes of the
6 user's fingerprint that are unique to the user, the system being capable of verifying
7 whether the unique attributes of the first fingerprint correspond sufficiently with

1 the unique attributes represented in the information in the output signal of the
2 sensor to verify said user is the first person, the device comprising:
3 a. a processing unit ; and
4 b. a template creation program stored in said processing unit, wherein said
5 program in cooperation with said processing unit creates a template, using the
6 information in the output signal from the fingerprint sensor, that represents in
7 less than 1K bytes of data sufficient unique attributes of a user's fingerprint
8 positioned proximate the sensor to permit the system to verify that the user is
9 the first person.

1 31. A device according to claim 30, further including one or more batteries for
2 providing all power requirements of the device.

1 32. A device according to claim 31, wherein said one or more batteries comprise 1.5
2 volt AAA batteries.

1 33. A device according to claim 30, wherein said processing unit includes non-
2 volatile memory for storing said unique attributes even when said one or more
3 batteries are removed.

1 34. A device according to 30, wherein said template creation program represents said
2 unique attributes of a user's fingerprint in less than 256 bytes of data.

1 35. A fingerprint identification device, comprising:
2 a. sensor for providing an output signal containing information representing
3 attributes of a user's fingerprint positioned proximate said sensor that are
4 unique to the user;
5 b. a memory for storing a first template containing attributes of a fingerprint of a
6 first person that are unique to the first person;
7 c. a logic unit connected to said memory; and
8 d. a program stored in said memory, wherein said program in cooperation with
9 said memory and logic unit:

- 1 i. creates said first template using the information in the output signal
2 from the fingerprint sensor that represents unique attributes of said first
3 person's fingerprint positioned proximate the sensor;
4 ii. creates a second template using the information in the output signal
5 from the fingerprint sensor that represents in less than 1K bytes of data
6 unique attributes of a user's fingerprint positioned proximate the
7 sensor; and
8 iii. verifies if said user is said first person by attempting to match said
9 unique attributes in said first template with said unique attributes in
10 said second template.

1 36. A device according to claim 35, wherein said memory stores first templates for a
2 plurality of fingerprints for a plurality of persons.

1 37. A device according to claim 35, wherein said memory includes non-volatile
2 memory for storing said first templates.

1 38. A device according to claim 35, further including one or more batteries as sole
2 power source for the device.

1 39. A device according to claim 35, wherein said device is designed to consume no
2 more than 1W peak power in verifying if said first person is said user.

1 40. A device according to claim 35, wherein said logic unit is a microcontroller.

1 41. A device according to claim 35, wherein said unique attributes in said first and
2 second templates each include:
3 a. x-y coordinates defining the position of minutia points in fingerprints of said
4 first person and said user, respectively;
5 b. type of each of said minutia points; and
6 c. direction of fingerprint ridges leading to each of said minutia points.

1 42. A device according to claim 35, wherein said information in said output signal of
2 said sensor includes images of ridges and valleys in said first fingerprint and said

- 1 user fingerprint that are represented with a plurality of gray scale pixel values for
2 an x-y array of pixels.
- 1 43. A device according to claim 42, wherein said program performs digital image
2 filtering of said images by:
3 a. generating an orientation number for local blocks of pixels in said x-y array of
4 pixels representing the approximate orientation of fingerprint ridges in said
5 local blocks; and
6 b. averaging each of said pixels in said x-y array with a number of adjacent
7 pixels that are selected as a function of said orientation number for the one of
8 said local blocks in which said each pixel resides.
- 1 44. A device according to claim 35, wherein said program, in connection with
2 attempting to match said unique attributes in said first and second templates,
3 corrects said unique attributes in said second template to account for at least one
4 of (a) variation in placement of a finger on said sensor and (b) expansion and
5 contraction of a fingerprint.
- 1 45. A device according to claim 35, further including an external unit connected to
2 said logic unit that is operable independently of other elements of the device when
3 said program verifies said user is said first person.
- 1 46. A device according to claim 45, wherein said external unit is physically remote
2 from said sensor and processing unit.
- 1 47. A device according to claim 45, wherein said external unit is physically proximate
2 said sensor and processing unit.
- 1 48. A method of creating a template containing attributes of a fingerprint unique to a
2 first person, the fingerprint having a plurality of minutia points of one or more
3 types and a ridge leading to each of the minutia points, the method comprising the
4 steps of:
5 a. identifying the location and type of a plurality of minutia points on the
6 fingerprint;

- 1 b. identifying the direction of the ridge leading to each minutia point; and
- 2 c. using no more than 1K bytes of data, storing said location and type of the
- 3 minutia points identified in step a and the direction of the ridge leading to each
- 4 minutia point identified in step b.

1 49. A computer readable media having a program embodied therein for directing a
2 computer to perform the steps of:

- 3 a. identifying the location and type of a plurality of minutia points on a
- 4 fingerprint including a plurality of ridges;
- 5 b. identifying the direction of the ridge leading to each minutia point; and
- 6 c. using no more than 1K bytes of data, storing said location and type of the
- 7 minutia points identified in step a and the direction of the ridge leading to each
- 8 minutia point identified in step b.

1 50. A system for comparing fingerprint information in a master template that
2 identifies unique fingerprint attributes of a registered person and fingerprint
3 information in a new template that identifies unique fingerprint attributes of a
4 user, wherein the fingerprint information in the new template is represented using
5 less than 1K bytes of data, the system comprising:

- 6 a. a memory for storing the master template and the new template;
- 7 b. a logic unit connected to said memory; and
- 8 c. a template comparison program stored in said memory and operable with said
- 9 memory and said logic unit to compare fingerprint information in said new
- 10 template with fingerprint information in the master template to determine if
- 11 the user is the registered person.

1 51. A fingerprint capture device comprising:

- 2 a. a fingerprint sensor for generating an output signal including an image of
- 3 ridges and valleys of a fingerprint positioned on said sensor;
- 4 b. a processing unit for storing said image, said processing unit connected to said
- 5 fingerprint sensor to receive said output signal;
- 6 c. one or more batteries that alone power the device; and
- 7 d. wherein said sensor and said processing unit together consume no more than
- 8 1W peak power.

- 1 52. A device according to claim 51, further wherein said processing unit modifies said
2 image to account for variations in said output signal from an absolute value
3 arising from at least one of (a) manufacturing variations and (b) expansion and
4 contraction arising from changes in pressure and environmental factors .

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